REMARKS

New claims 77-103 have been added. Claims 43-47, 49-56, and 67-97 are pending. Claims 43, 49, 53, 77, 84 and 91 are independent. Support for the new claims can be found throughout the specification, for example at page 6, lines 7-9, at page 7, line 24, at page 10, lines 7-8, and at pages 9-12. No new matter has been added.

Withdrawn rejections

Applicants thank the Examiner for withdrawing the rejections with respect to U.S. Patent No. 5,537,000, to Alivisatos et al. under the judicially created doctrine of obviousness-type double patenting, 35 U.S.C. § 102(b), and 35 U.S.C. § 103(a). See the Advisory Action mailed April 13, 2004.

Obviousness-type double patenting rejections

Claims 43-47, 49-56, and 67-76 have been rejected under the judicially created doctrine of obviousness-type double patenting over either claims 1-31 of U.S. Patent No. 6,322,901 ("the '901 patent") or claims 1-20 of U.S. Patent No. 6,207,229 ("the '229 patent") in view of U.S. Patent No. 6,057,561 to Kawasaki et al. ("Kawasaki"). Specifically, the Examiner contends that

> '901 and '229 are claiming a single nanocrystal while the present invention is claiming a group of these same nanocrystals that are grouped together, forming a gain medium for use in a laser system.... Kawasaki teach[es] that it is well known that nanocrystals exhibiting photoluminescence are often grouped together into a gain medium and formed into a laser.

See the Office Action at pages 2-3. Applicants respectfully disagree.

Applicants have discovered a laser, a method of amplifying an optical signal, and a method of forming a laser, each of which includes a concentrated solid including a plurality of semiconductor nanocrystals, the plurality of semiconductor nanocrystals being close-packed. See independent claims 43, 49, and 53.

A finding of obviousness requires (i) a suggestion or motivation to combine the references, (ii) a reasonable expectation of success, and (iii) that the references teach all of the claimed limitations. See MPEP § 2143. The combination of either the '901 patent or the '229 patent with Kawasaki fails to meet these criteria.

The nanocrystals described by Kawasaki are formed by laser molecular beam epitaxy on a sapphire substrate upon which a thin film of semiconductor (e.g. ZnO) is grown. Specifically, Kawasaki describes laser molecular beam epitaxy as "a method in which solid substance is excited into a high energy plasma state in vacuum and is then condensed and deposited on a substrate." See Kawasaki at column 10, lines 30-33. In general, molecular beam epitaxy requires the exposure of a solid substrate (e.g. sapphire) to a plasma or vapor generated from a solid at high temperatures (e.g., 600 °C) and low pressures (e.g., 5×10^{-5} Torr). For example, Kawasaki describes:

> The formation of thin film for II-oxide optical semiconductor elements was carried out in accordance with a laser molecular beam epitaxy method. A KrF eximer laser (wavelength: 248 nm, pulse frequency: 10 Hz) was used, and the power of laser was set to 0.9 J/cm^2. Through use of a ZnO sintered body containing 0 to 18 mol % of magnesium a film was formed on the sapphire substrate (0001) at a filming temperature of 600 °C. and an oxygen partial pressure of 5×10^{-5} Torr.

See Kawasaki at column 9, lines 50-57. Kawasaki describes the thin film having nanocrystals grown on a substrate with average diameters of 45 nm to 257 nm, with a size variation of 33 to 37.3%. See Kawasaki at, for example, column 5, lines 62-67; column 6, lines 23-24; and at FIGS. 1, 2, 3, 4 and 5. The nanocrystals are linked to the sapphire substrate. See Kawasaki at FIGS. 7 and 8, and at column 6, line 61 - column 7, line 23, discussing the lattice matching between ZnO and the sapphire substrate.

In contrast, the nanocrystals described in the '901 patent and the '229 patent are made by a colloidal growth process, involving "rapid injection of the appropriate organometallic precursor into a hot coordinating solvent." See the '901 patent at column 4, lines 61-63. No vacuum is required, no substrate is used to grow the nanocrystals, and the temperatures used during nanocrystal preparation are lower than those described in Kawasaki (see the '901 patent, for example, at column 9, lines 10-26). The nanocrystals have diameters of 2-12.5 nm and have a narrow distribution of diameters, for example less than 10% rms deviation in diameter. See the '901 patent at, for example, column 2, lines 56-62. The outer surface of the nanocrystals can have an organic layer including compounds that facilitate dispersion of the nanocrystals in different solvents. See the '901 patent at, for example, column 7, lines 9-30.

The nanocrystals of the '901 patent and the '229 patent are characterized by size-dependent photoluminescence spectra. See the '901 patent at, for example, FIGS. 2 and 3. The nanocrystals have radii "smaller than the bulk exciton Bohr radius.... Quantum confinement of both the electron and hole in all three dimensions leads to an effective increase in the band gap of the material with decreasing crystallite size. Consequently, both the optical absorption and emission of quantum dots shift to the blue (higher energies) as the size of the dots gets smaller." See the '901 patent at column 1, lines 25-34.

The nanocrystals of Kawasaki, however, do not show any evidence of quantum confinement. Indeed, the photoluminescence spectra presented at FIG. 9, recorded with nanocrystals having an average diameter of 45 nm, shows a peak energy of ~3.15 eV (peak labeled 'N'), whereas the spectra of FIG. 10, for nanocrystals having an average diameter of 257 nm, shows a higher peak energy of ~3.17 eV. Higher energy for larger nanocrystal size is the **opposite** of the expected effect if quantum confinement were occurring.

Table 1 below summarizes properties of nanocrystals described in the '901 and '229 patents and in Kawasaki.

Table 1

Reference:	'901 or '229	Kawasaki
synthesis	colloidal growth	molecular beam epitaxy
average diameter	2-12.5 nm	45-257 nm
variation in diameter	<10% rmsd	≥33%
quantum confinement	yes	no
organic layer on outer surface	yes	no
solvent dispersable	yes	no
fixed to substrate	no	yes

There is no suggestion or motivation to combine the references. MPEP 2143.01 states that "[o]bviousness can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion or motivation to do so found either explicitly or implicitly in the references themselves or in the knowledge generally available to one of ordinary skill in the art." There is no explicit suggestion or motivation in the references to combine either the '901 patent or the '229 patent with Kawasaki. Furthermore, "'[t]he test for an implicit showing is what the combined teachings, knowledge of

one of ordinary skill in the art, and the nature of the problem to be solved as a whole would have suggested to those of ordinary skill in the art'" (emphasis added). See MPEP 2143.01, citing *In re Kotzab*, 217 F.3d 1365, 1370, 55 USPQ2d 1313, 1317 (Fed. Cir. 2000).

The nanocrystals described in the '901 and '229 patents are so different in size, variability of size, synthesis, and chemical and physical properties from those described in Kawasaki (see Table 1), that a person of ordinary skill in the art would not have been motivated to combine the teachings of the references. Teachings relating to nanocrystals formed epitaxially on a substrate would not motivate a person of ordinary skill in the art to use nanocrystals that are formed by colloidal growth, and vice versa. Thus, the claims are non-obvious in view of the cited references.

Furthermore, even if there *were* a motivation to combine, a person of ordinary skill in the art would not have a reasonable expectation of success. The '901 and '229 patents teach the synthesis of colloidal nanocrystals, but do not teach how to make a concentrated solid including a plurality of semiconductor nanocrystals. In particular, there is no teaching or suggestion of a concentrated solid including close packed semiconductor nanocrystals. Nor do the '901 and '229 patents teach a laser, a method of amplifying an optical signal, nor a method of forming a laser, including a gain medium comprising a concentrated solid including a plurality of semiconductor nanocrystals where the plurality of semiconductor nanocrystals are close-packed. Kawasaki does not remedy these defects.

Kawasaki does not teach how to make a concentrated solid including close-packed nanocrystals using the **colloidal** nanocrystals described by the '901 or '229 patents. Kawasaki describes close packed nanocrystals formed on a substrate by molecular beam epitaxy. According to Kawasaki, the nanocrystals form as a close packed group of nanocrystals at the time they are formed on the substrate. See Kawasaki at, for example, FIGS. 1, 7 and 8. There is no teaching or suggestion in Kawasaki of how to manipulate colloidal nanocrystals to form a concentrated solid including a plurality of semiconductor nanocrystals where the plurality of semiconductor nanocrystals are close-packed. Indeed, the method taught by Kawasaki for forming close packed nanocrystals is **incompatible** with the semiconductor nanocrystals taught in the '901 and '229 patents. Therefore, the combination of Kawasaki with either the '901 or '229 patents **would not provide** a person of ordinary skill in the art **a reasonable expectation of**

success. Without the requisite reasonable expectation of success, the claims are not obvious over the combination of either the '901 or '229 patents with Kawasaki.

Applicants respectfully request reconsideration and withdrawal of the rejections under the doctrine of obviousness-type double patenting.

New claims 77-103

New claims 77-103 have been added. Claims 77, 84, and 91 are independent. Each of the new independent claims recites a concentrated solid including a plurality of colloidally grown semiconductor nanocrystals, the plurality of semiconductor nanocrystals being close-packed and having an rms deviation in diameter of less than 15%. The concentrated solid can be disposed on a substrate, where the substrate is made from a material that does not react with the nanocrystals (see claims 84, 93, and 102). As discussed above, Kawasaki describes nanocrystals linked to a sapphire substrate. The nanocrystals can be substantially spherical in shape (see claims 85, 94, and 103). Kawasaki describes that "the nanocrystal has a hexagonal-prism-like shape" (see Kawasaki at column 6, lines 54-56). No new matter has been added. The new claims are patentable over the cited references.

CONCLUSION

Applicants ask that all claims be allowed. Please apply any other charges or credits to deposit account 19-4293.

Respectfully submitted,

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